

**High Resolution Simulation and Comparison of  
Shallow Cumulus Clouds Observed during  
the TWP-ICE, AZORES, and RICO Experiments**

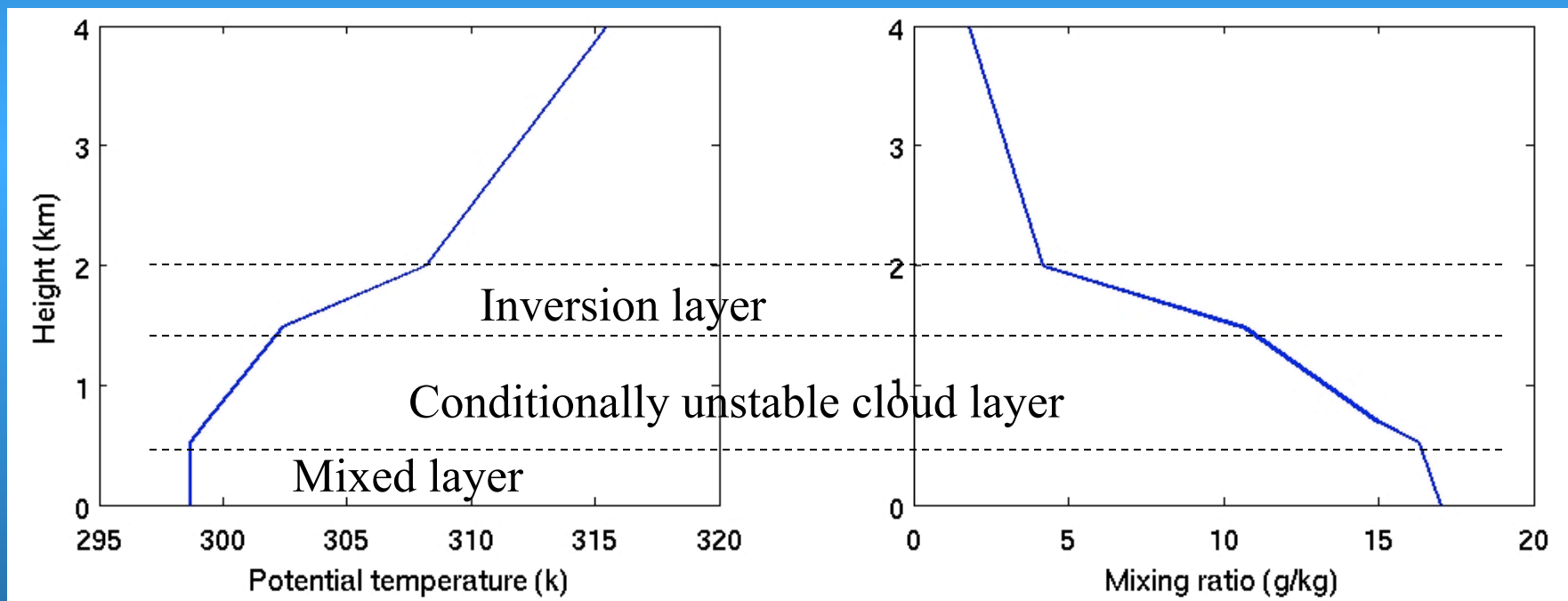
**Ping Zhu**  
**Florida International University**

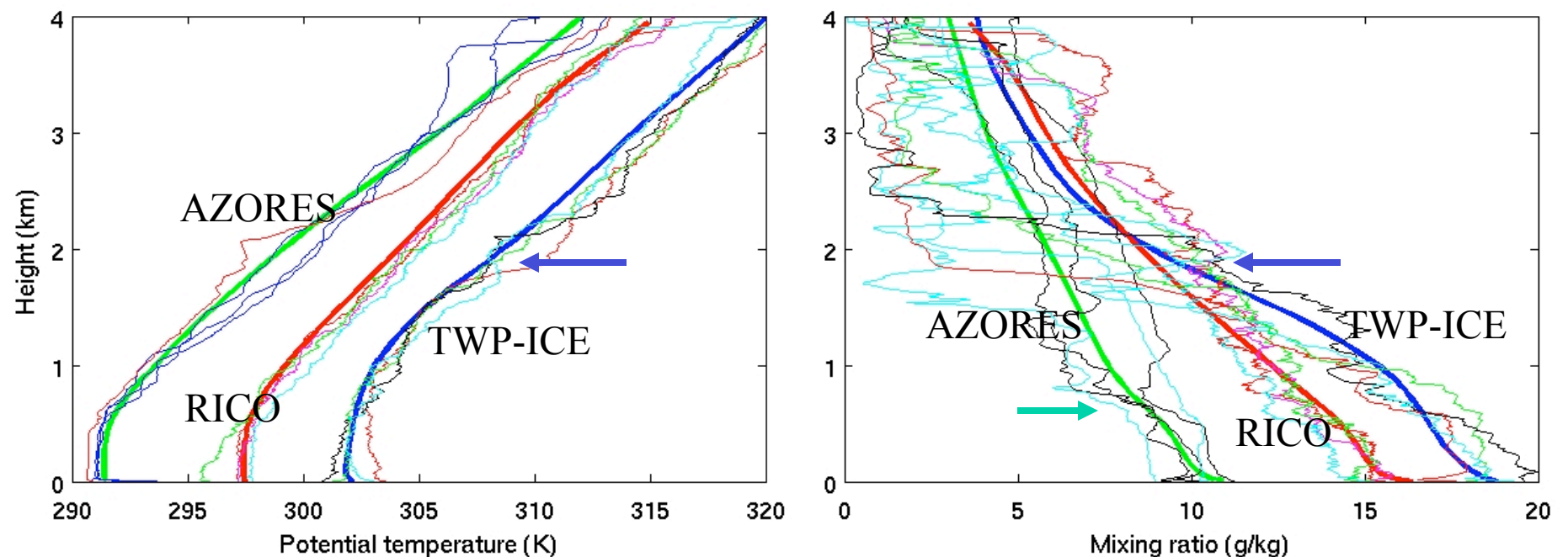
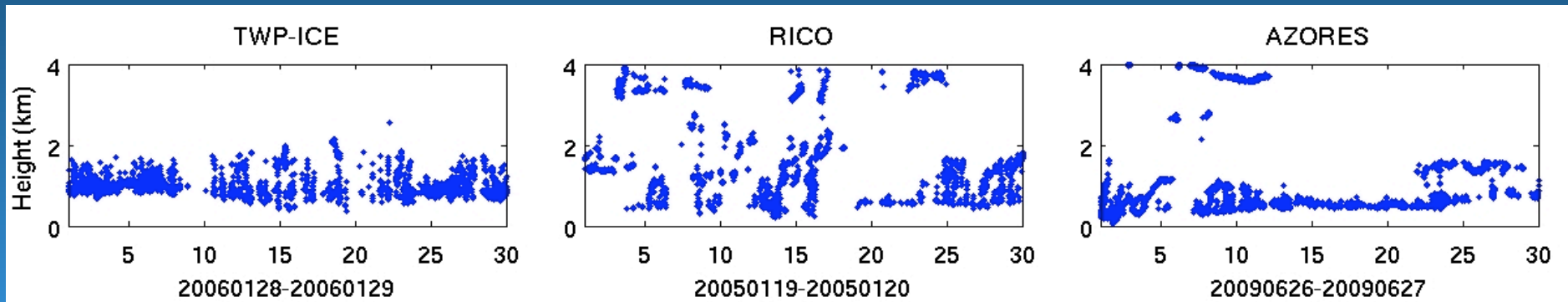
**Bruce Albrecht, Paquita Zuidema**  
**University of Miami**

**Virendra P. Ghate**  
**Rutgers University**

## Mass flux approach for cumulus parameterization

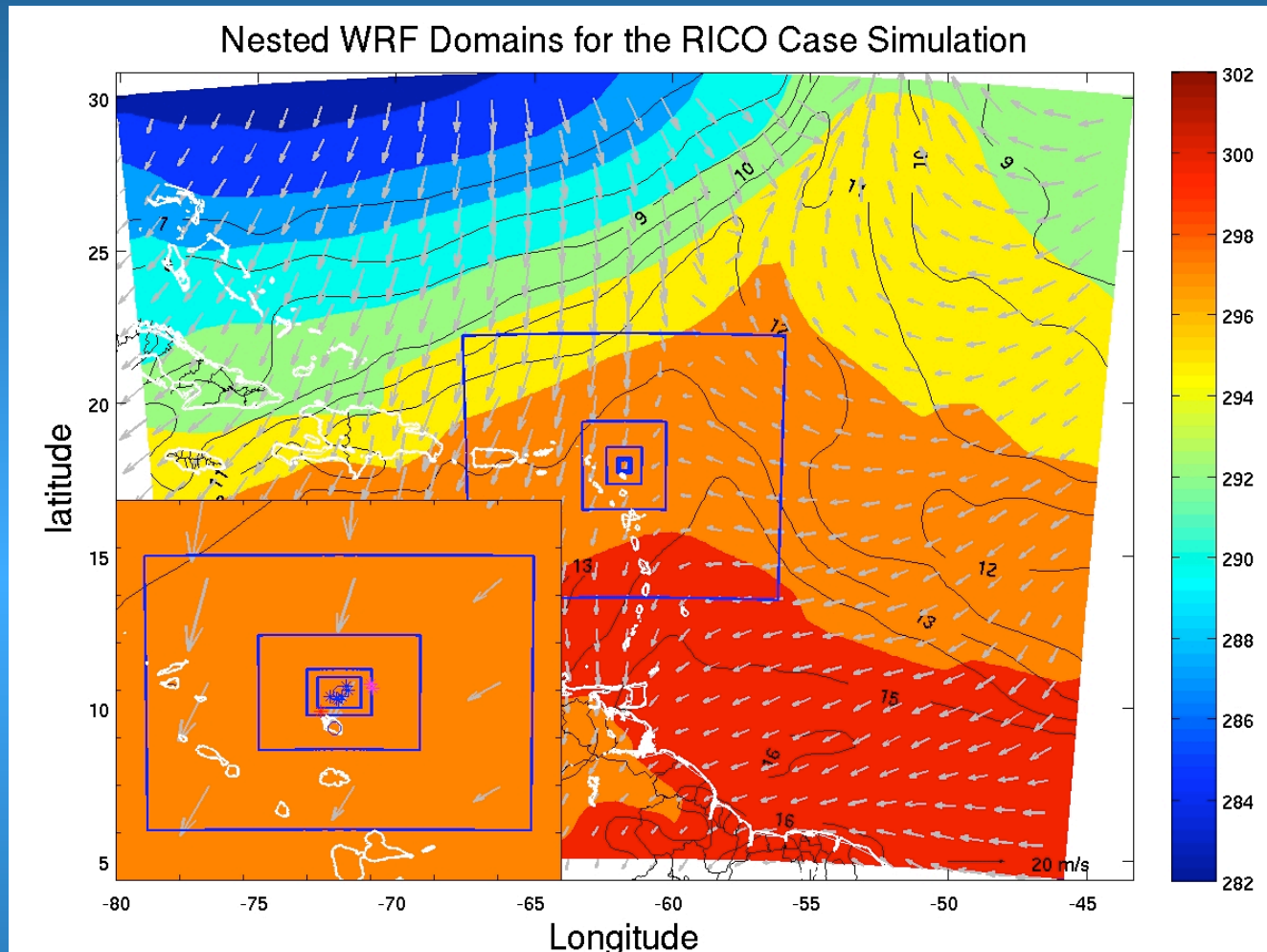
The organized cloud updraft and compensating downdraft are responsible for vertical transport in cloud layer





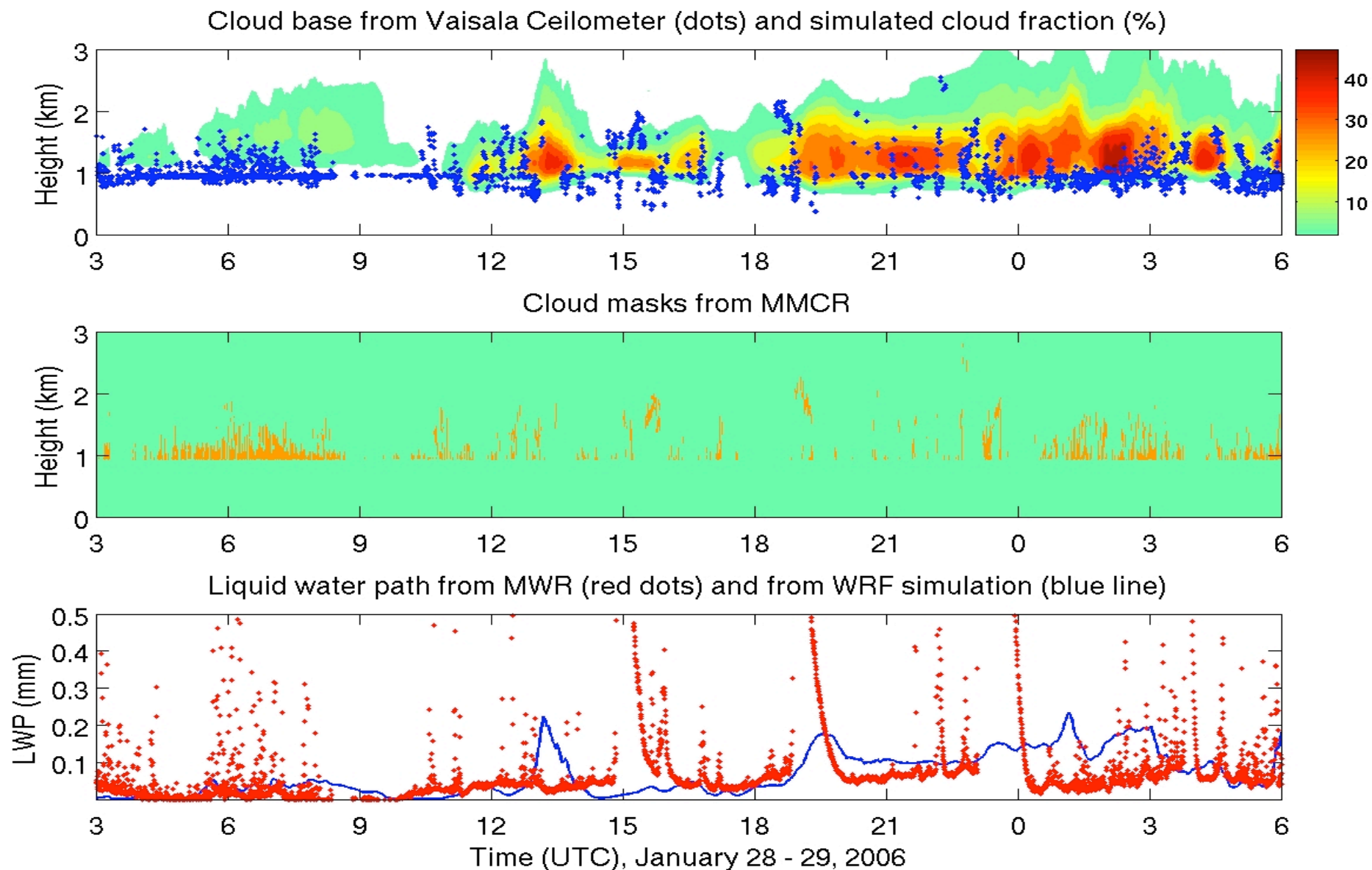
Is the basic assumption of mass flux approach for representing shallow cumuli still valid when the ambient atmospheric stratification deviates substantially from the classic undisturbed trade-wind condition?

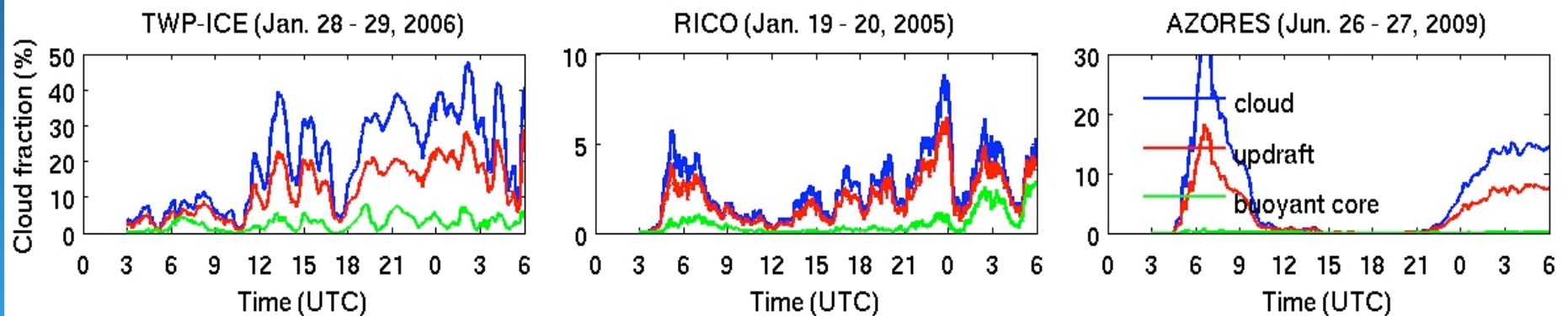
# Multiple nested WRF simulation framework



Parent domain: 24.3 km; Nesting ratio: 1:3; Innermost domain: 100 m  
Vertical resolution: 6 – 100 m below 3km  
Innermost domain mesh-grid: 361 x 361

# TWP-ICE Case





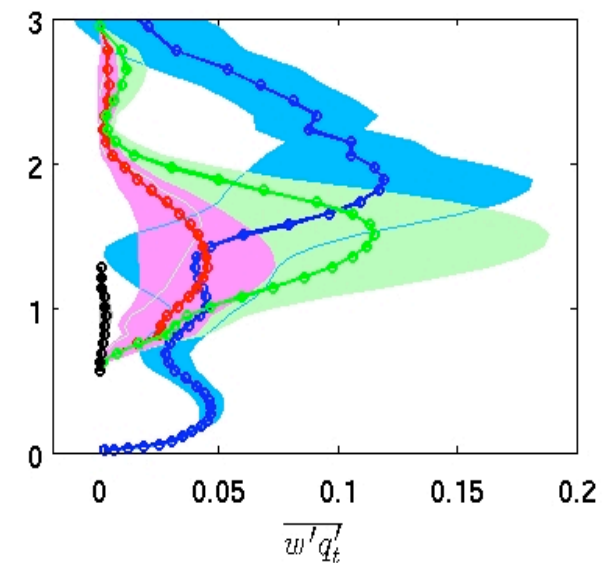
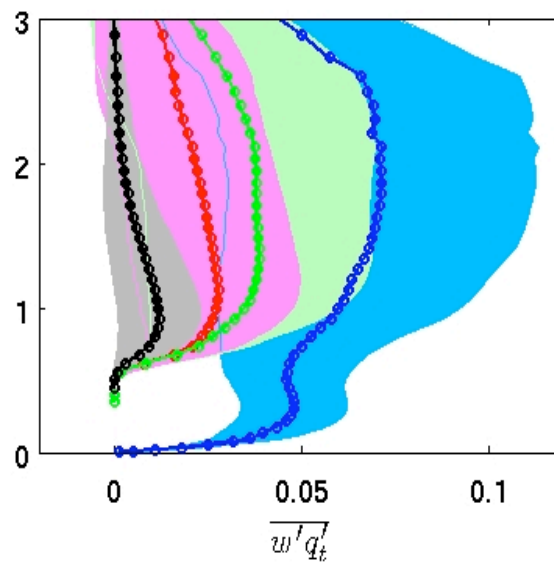
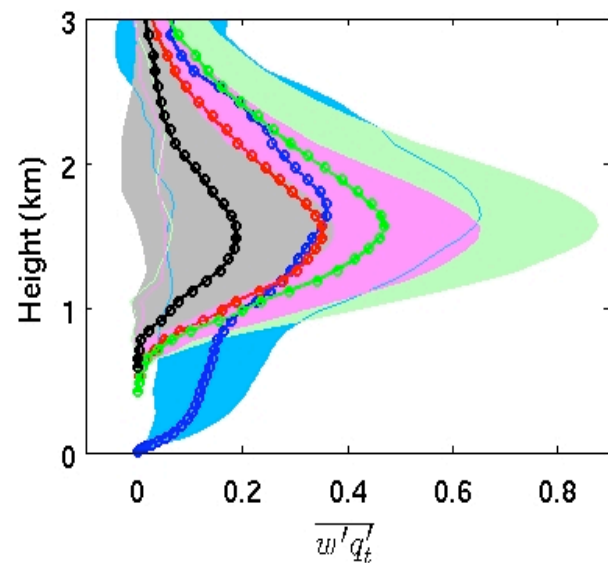
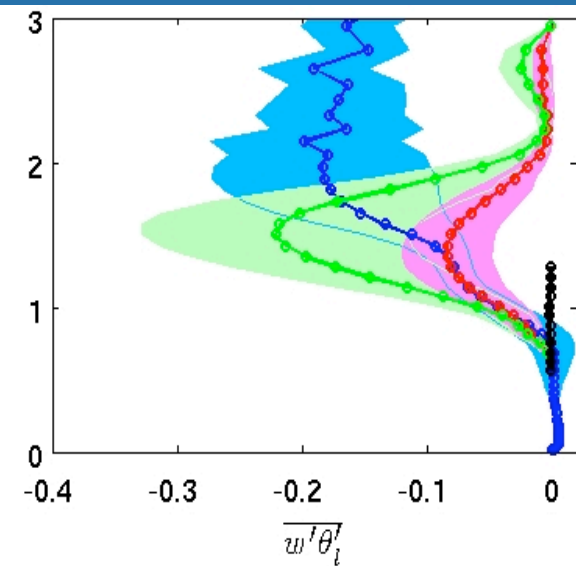
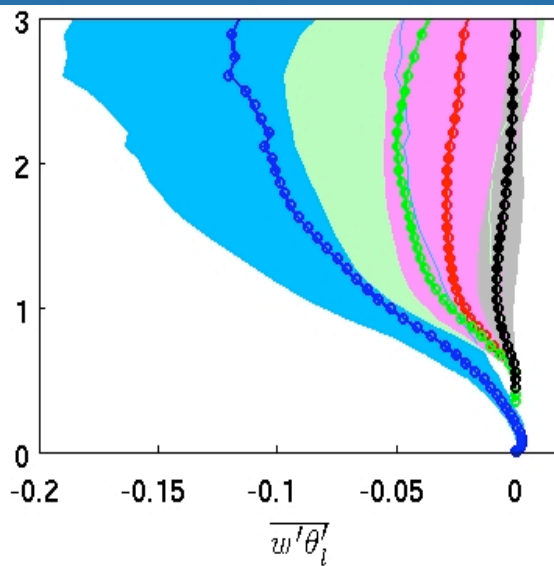
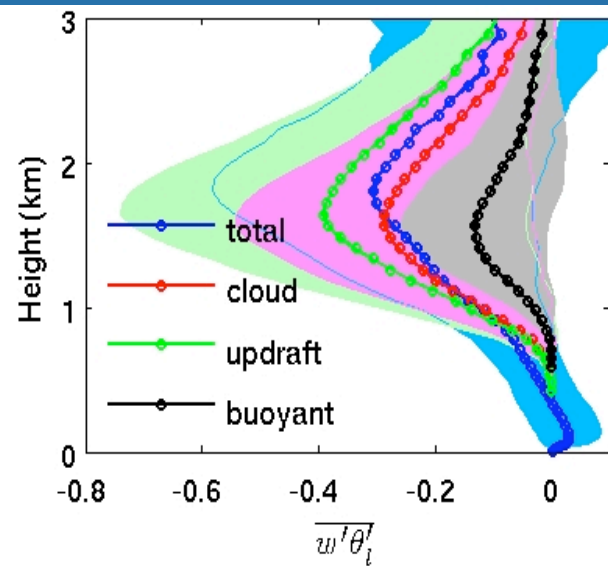
**In-cloud turbulence,  
Environmental turbulence,  
Organized structures.**

**Cloud decomposition,  
Cloud and updraft decomposition,  
Buoyant core decomposition.**

# TWP-ICE

# RICO

# AZORES

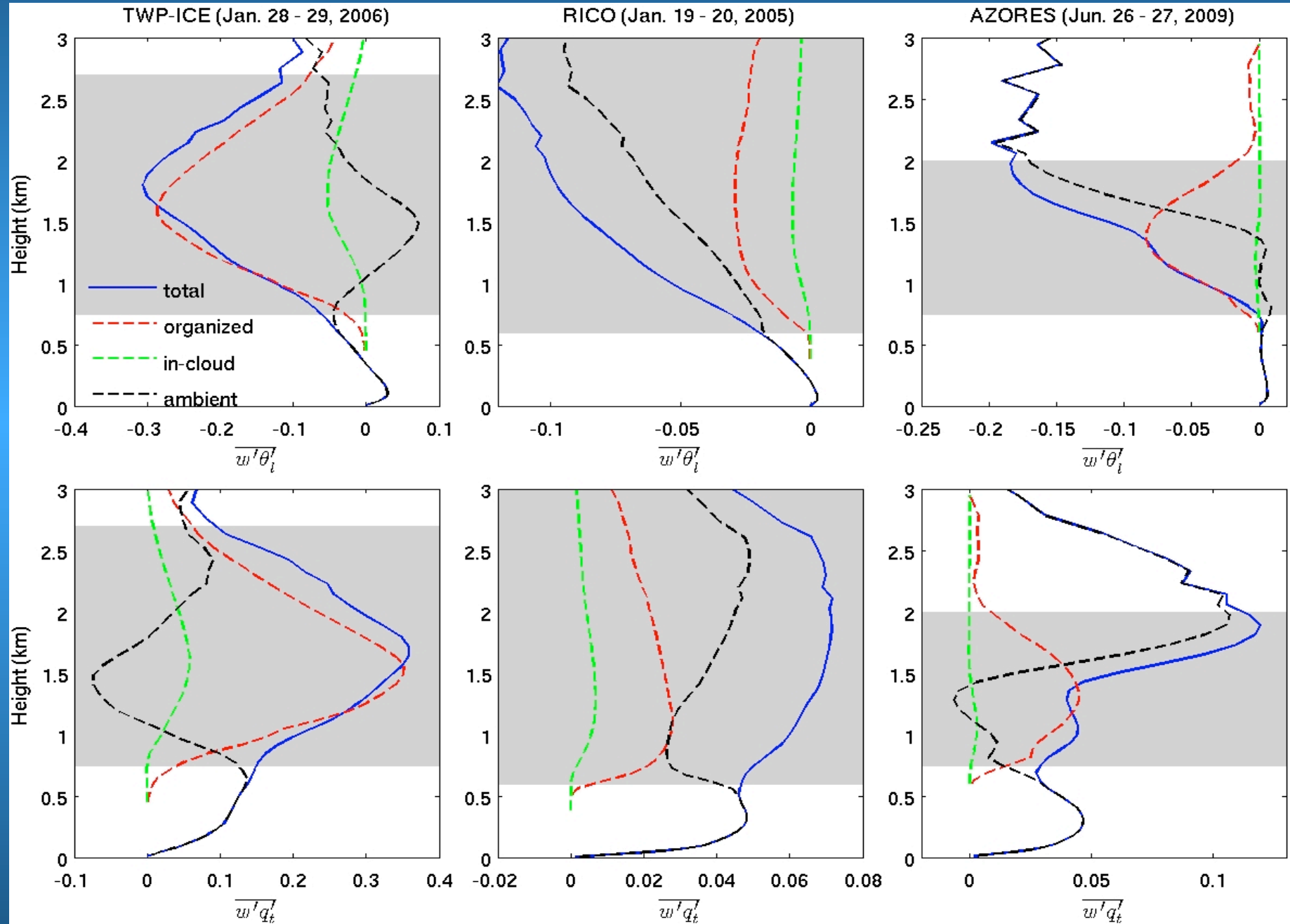




# TWP-ICE

# RICO

# AZORES

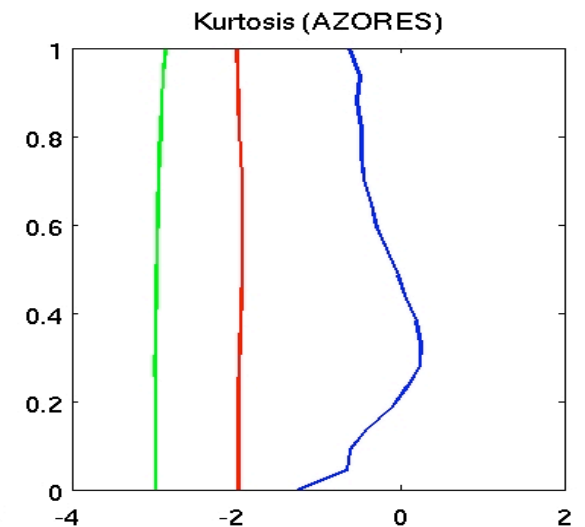
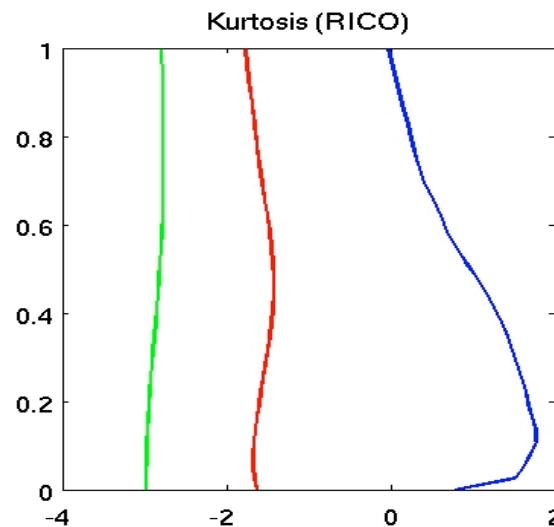
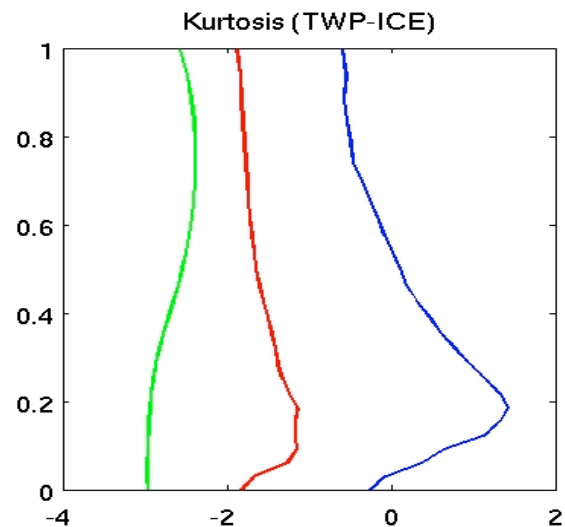
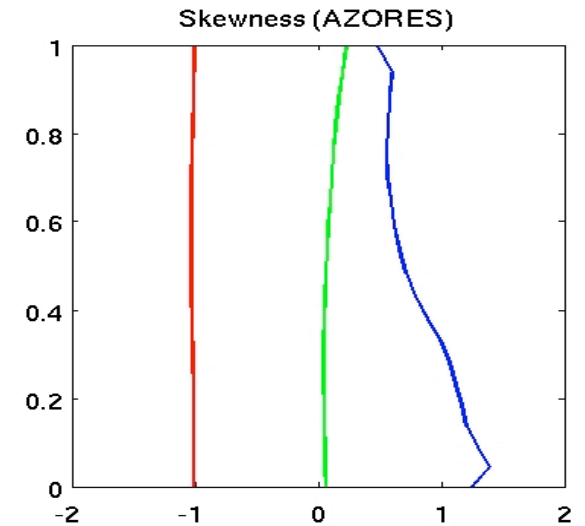
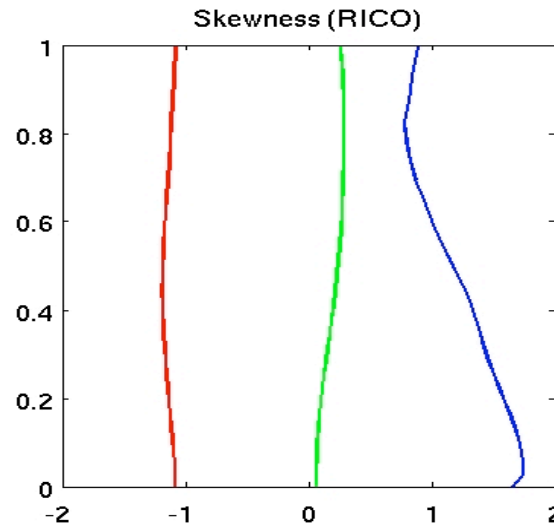
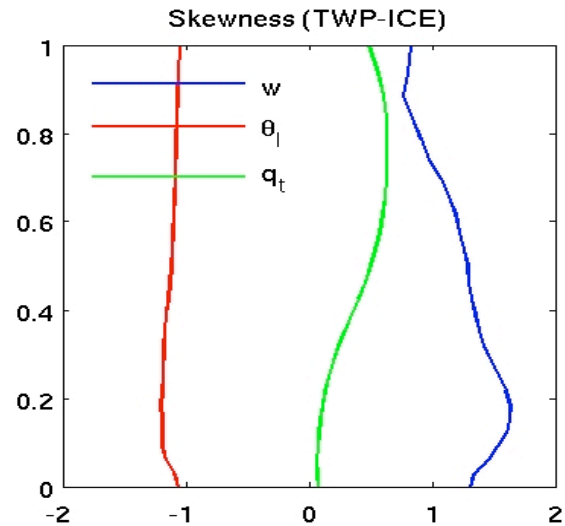




## TWP-ICE

## RICO

## AZORES



Vertical height has been normalized by cloud base and top

$$(Z - Z_{cbase}) / (Z_{ctop} - Z_{cbase})$$

## Summary

1. WRF-LES can realistically reproduce the observed clouds in various meteorological conditions.
2. The assumption that the organized structures are responsible for the vertical transport in the cumulus layer works fine in some conditions, while it may easily fail when the ambient turbulent transport is strong.
3. The dynamic and thermodynamic variables do not follow the same PDF distribution in the clouds. Each has its own statistical characteristics.